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SAFETY FORUM

SAFE SUSTAINABILITY

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Safety Forum Summary

FROM INDUSTRY – FOR INDUSTRY

The theme of the 2022 Safety Forum "Safe Sustainability" involves more aspects of sustainability than just environment. The International Civil Aviation Organization (ICAO) mapped its strategic objectives to 15 of the 17 United Nations Sustainable Development Goals (UN SDG). The aviation system is a key enabler for the global economy, connectivity, infrastructure improvement and the expansion of trade and tourism. In this way, the aviation system profoundly supports the UN SDG. The focus of the Safety Forum discussions was however mainly related to ICAO Environment Strategic Objective, UN SDG 13 "Take urgent action to combat climate change and its impacts" and UN SDG 3 "Ensure healthy lives and promote well-being for all at all ages".

The conclusions of the 2022 Safety Forum reflect the understanding that there will be different pressures on the aviation system originating from climate change, the actions to combat climate change's impact and from actions taken to protect the environment. The identified generic types of pressures can have safety effects if the aviation system is not resilient enough to properly manage them. We discuss typical aviation system resilience capabilities to counterbalance the different types of pressures. This is not the end but the beginning of a structured and comprehensive conversation that needs to take place in the industry.

To ensure the aviation system's overall positive effect on global sustainable development, it is important to balance the long-term positive effects aviation has on the global economy, social development, inclusiveness, equitability and infrastructure development against the different pressures on the aviation system to manage its environmental impact. To achieve that, it is key for the industry to promote and develop an integral culture of sustainability that includes safety, environment and social aspects. Such culture is characterised by a system design with sufficient safety margins, providing information and knowledge to front end professionals and empowering them to make balanced decisions based on real-time risk management.

Hereafter are the typical safety-related pressures on the aviation system originating from climate change, the potential actions to combat its impact and from actions for environmental protection. The identified pressures and example resilience capabilities are not guidelines or recommendations but represent a factual summary of what was presented and discussed during the 2022 Safety Forum. Aviation organisations are encouraged to review the information contained in this document and to assess the relevance of this information against their local conditions and specific context.

1. **Pressures on the aviation system to reduce its carbon footprint:**

PRESSURES ON THE AVIATION SYSTEM	EXAMPLE RESILIENCE CAPABILITIES TO RESPOND TO THE PRESSURES
Single engine taxi-out could affect the safety of operations.	Aircraft operators perform risk assessment for single engine taxi considering the estimated taxi time, and operation environmental conditions to determine mitigation measures accordingly. Within the risk assessment, aircraft operators consider the possibility of: disruption of flight crew normal task flow and contribution to the chance of aircraft misconfiguration and lack of or loss of critical situational awareness for the subsequent take-off and departure; excessive jet blast to achieve wheel un-stick; accidental single-engine take-off; creation of adverse thermal cycles in engine components; failure to develop standard operating procedures (SOP) and checklists to avoid cancelled take-offs and/or malfunctions; increased corrosion on aircraft components on the side of the non-running engine/propeller due to absence of propeller propwash as a result of single-engine taxi (inadequate performance of vent systems); strong asymmetric force generated by greater jet blast from single engine leading to unbalancing the aircraft and possible tire wear; shutdown of key plane functions when turning engines on and off; increased workload; heads-down activity; controllability issues on slippery taxiways; distraction in case of start malfunction; effect of failed systems (MEL or inflight); fuel imbalance. Aircraft operators, when considering implementation of single engine taxi-out and single engine taxi-in, provide their flight crews with training and robust procedures preventing time-pressure and stress for the flight crews and consider making the single engine taxi procedure optional for flight crews. To facilitate a second engine start during the very busy taxi, the procedures in place allow the crew to be more consistent in their duties (e.g., standardised flight crew roles). Air navigation service providers (ANSPs) adapt operational procedures to take into account mixed traffic, involving singe engine taxi operations. Single engine taxi-out traffic may need more time at holding point. ANSPs expect capacity restrictions when flight crews use single engine taxi-out and plan accordingly. Possible trouble shooting after system malfunctions has to be done on the taxiway and when the aircraft is at full stop. Planning addresses the possible increase in the number of vehicles on the taxiway and the possibility a taxiway being blocked for some time if the aircraft has to be towed. Pilots are provided with timely and accurate information about expected take-off time, which allows them to start engines at the optimum time before take-off. Original equipment manufacturers (OEMs) provide for automatic-starting

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	systems that reduce crew workload during engine start and enable crew to start engines safely while performing their normal crew duties during taxi. Additional pressures are considered in determining the operational use of a single engine taxi out – e.g., during fog/winter weather or taxiway/runway slippery conditions; when aircraft too heavy, in the presence of system degradation, increased levels of fatigue or workload and during training. Expectation and adjustment by setting aircraft configuration like flaps prior to taxi.
The use of sustainable aviation fuel (SAF) could contribute to an increase chance of flame out when used by uncertified or technically unfit aircraft.	Fuels are certified in order to be used in commercial flights. Airport operators and fuel suppliers use separate storage and handling of both sustainable aviation fuel (SAF) and conventional aviation fuel types and perform careful management of aircraft refuelling to prevent uploading the wrong fuel (this is specifically important when SAF is available in blends >50%). Aircraft operators and aircraft manufacturers ensure that the older aircraft which are not certified for 100% SAF are retrofitted and made SAF compatible. Fuel auditing is adapted. This involves training and understanding of new fuels.
Pressure to reduce the fuel reserves could lead to reduced safety margins, increased operational pressure and workload affecting decision making and increase the likelihood of diversion, low fuel situations and associated emergencies.	Aviation industry develops and promotes guidelines that make clear distinction between carriage of extra fuel for economic or commercial/operational reasons and extra fuel uplift – which is at the crew's discretion due to factors such as weather or anticipated holding at destination, etc. Aircraft operators preform risk management for reduction in fuel reserves carried on every flight. Aviation regulators and aircraft operators ensure that the right of the flight crew to decide on the fuel deemed necessary for a flight is not restricted. Aircraft operators ensure providing their flight crews with accurate flight plan based on realistic data of aircraft fuel consumption, weather, expected routing and traffic. Aircraft operators have fuel monitoring programs to identify excessive consumption and significant deviation from planned fuel consumption.
Pressure to save fuel in flight could lead to increased risk of turbulence encounter or increased risk of loss of control events.	Aircraft operators ensure that their operations manuals contain clear and unrestricted policies for avoiding turbulence and enroute weather. Aircraft operators invest in technologies to present real-time turbulence data to crews to enable them to avoid turbulence using the most efficient routes and altitudes.

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Pressures to have most efficient flight trajectories could affect air traffic complexity.	ANSPs understand the holistic nature of operational performance (e.g. changing aircraft efficiency impacts safety and capacity.) ANSPs understand the contributing factors with each aspect of operational performance. ANSPs provide most efficient horizontal flight trajectories (e.g., free route airspace in Europe). ANSPs provide most efficient vertical flight trajectories. ANSPs are aware and reflect in their operating practice the fact that reducing fuel burn in flight is effectively reducing the aircraft speed. New, sustainability-driven, operational concepts (for example, formation flying) are assessed for their impact on air traffic management complexity and safety risks. ANSPs develop strategies to offer more capacity where there is less aircraft fuel consumption (in specific altitude range or areas). Aircraft operators provide flight plans that reflect the expected trajectory and adhere to the planed trajectory to the maximum extent possible to enable ANSPs to take the expected trajectory into account.
Pressures to save fuel on approach, for example by landing with idle reverse thrust, use of minimum landing flaps or late gear selection and use of continuous descent approaches could affect the most optimal landing performance especially if combined with other pressures like poor weather or performance limited runways, and could increase the risk for runway excursion.	Aviation regulators and aircraft operators ensure that performance calculations are carried out before every approach, taking into account the expected weather and runway state, expected landing configuration and braking method and any system malfunctions that may affect the stopping capability. Aviation regulations and operational procedures ensure that the right of flight crew operational decision on approach and landing performance is not restricted. Aircraft operators perform risk assessment for the measures to save fuel on approach to determine mitigation measures accordingly. Within the risk assessment, aircraft operators consider the possibility of late stabilisation; rushed approaches; unforeseen tailwind or icing; over-reliance on VNAV;, runway overrun; increased brake and tire wear; missing the planned turn-off causing following traffic go around. Aircraft operators, when considering implementation of fuel saving measures on approach (e.g., landing with idle reverse thrust, use of minimum landing flaps or late gear selection and use of continuous descent approaches), provide their flight crews with training and robust procedures and consider making the procedure optional for flight crews.
Pressures to save fuel by reducing the total lift required through aft CG (centre	Aircraft operators perform risk assessment for the measures to save fuel by reducing the total lift required through aft CG loading to determine mitigation

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of gravity) loading (load aftward) could increase the risk of degraded stall recovery performance, tail tipping and tail strike.	measures accordingly and have loading schedules which take these measures into account and provide for adequate curtailment of the CG envelope. Aircraft operators, when considering implementation of fuel saving measures by reducing the total lift required through aft CG provide their flight crews ad relevant personal with training and robust loading and boarding procedures and consider making the procedure optional for flight crews.
Pressures to save fuel by increased take off and climb thrust could increase the risk of engine wear, greater asymmetry in case of engine failure, affected contaminated runway minimum control speed and increased foreign object debris (FOD) damage on the runway.	Aircraft operators perform risk assessment for the measures to save fuel by increased to and climb thrust to determine mitigation measures accordingly. Aircraft operators, when considering implementation of fuel saving measures by increased take off and climb thrust provide their flight crews with training and robust procedures and consider making the procedure optional for flight crews.
Pressures to reduce the aircraft generated condensation trails (contrails) resulting in in air traffic control (ATC) operational procedures to provide instruction to avoid specific contrail inductive airspace could impact air traffic controllers' workload and increase the risk of aircraft significant weather encounter.	Air traffic control capacity planning and management takes into account ATC operational procedures to provide instruction to monitor for and avoid specific contrail inductive airspace. Trajectory planning by aircraft operators and ATC carefully balancing against the risk in assigning cruise flight levels potentially counterproductive to safety and efficiency aims (less fuel efficient cruise levels, more exposure to significant weather (turbulence, jet streams, convective weather hazards (thunderstorms, hail, lightning), circumnavigation of which increases flight time/fuel burn/emissions).
All electric flights could introduce pressures related to, including, battery fire and thermal runway, motor failure, toxic fumes, personal exposure to high voltage or current, battery energy uncertainty, battery charging safety, energy regeneration hazards, common mode failures, battery aging, battery performance variability with temperature.	Certification of electric propulsion systems including the Special Conditions that regulators are in the process of establishing. Design organisations are aware and address through the newly established certification process of electric propulsion systems the issues, including: the limitation and specificities related to battery charging; the issues related to energy reserves - remaining battery capacity and how this corresponds to range and endurance; the battery temperature sensitivity and limitations; the maintenance-related issues like arcing, short cuts, damage and fire hazards when working on electric systems and the specifics of fighting an electric fire (including specifics of Li-ion firefighting - need for containment and low possibility to extinguish, the electroshock hazard when using liquid for cooling). Electric flight operators are aware and address through their risk management process the issues related to electric propulsion systems.
Hydrogen powered flights could	Design organizations are aware, and address through the newly established

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introduce pressures related to new types of fires, new infrastructure with associated procedures and technologies, fuel cell fires or explosions, new cryogenic hazards and new fuelling procedures.	certification process for hydrogen fuelled aircraft, the specific hydrogen fuel cells flights pressures related to, including, increase in weight or increase in tank size, fuel contamination, fuel cell overheat, unintentional release of H2 or H2O, liquid H2 low temperature, fuel cell fire, fuel cell explosion, asphyxiation. Firefighting practices and procedures and operational procedures evolve to address the new hazards related to hydrogen fuel. Hydrogen is colourless, odourless and very buoyant presenting radically different properties and behaviours to hydrocarbon-based fuels. Technology is developed and used to detect hydrogen release. It is likely that new procedures and technologies will be needed to respond effectively to hydrogen fires or explosions. Aircraft may need to allow release of hydrogen fuel prior to landing in an emergency to protect life. Hydrogen has a very low minimum ignition energy and therefore requires anti-static and fire-retardant personal protection equipment. Hydrogen fuels cells flights operators are aware and address through their risk management process the specific hydrogen fuel cells flights pressures. Airport operators are aware and address through their risk management processes the specific hydrogen fuel cells flights pressures. This includes but is not restricted to risk assessment of the refuelling procedure and its specific hazards especially in the neighbourhood of airport passenger terminals or during the operations of boarding and un-boarding of passengers. Risk assessment and management addresses the impact of the new hazards related to hydrogen fuel on aircraft refuelling, maintenance and evacuation procedures. An information system is developed and used (e.g., by modification of the flight plan system) to indicate for planning purposes the type of fuel used by the aircraft.

2. Pressures on the aviation system stemming from the climate change developments outside aviation:

PRESSURES ON THE AVIATION SYSTEM	EXAMPLE RESILIENCE CAPABILITIES TO RESPOND TO THE PRESSURES
Wind turbine installations could create hazards for aircraft operations or for air traffic management system (ATM).	Aviation regulators cooperate with wind farm relevant regulators and operators to ensure risk of affecting ATM surveillance capability is properly addressed. Aviation safety site-specific risk assessment is performed for hazards arising from wind turbine installations in the vicinity of airports/airfields. The risk assessment includes impact on visual and instrument flight procedures, turbulence / aerodynamic effects, obstacle limits, effects on communication, navigation and surveillance (CNS) equipment (e.g., DVOR). Wind turbine protection zones (VFR) due to turbine-induced turbulence are implemented wherever needed and considered during flight procedure and airspace design. Aircraft detection lighting systems (ADLS) for wind turbines during night (e.g., based on transponder signals) are implemented if detection capabilities in the vicinity of wind turbines needs to be assured (e.g., at runways or final approach and take off areas). Proper mitigation measures (e.g., temporarily lock/shut down or Y-position of wind turbines) are developed after a site-specific risk assessment. Aviation regulators establish a risk assessment framework to ensure a consistent standard of evaluation in identifying risks and deriving risk mitigation measures.
Increased use of electric ground service equipment (GSE) could change the fire vulnerability at the airport.	Firefighting practices and procedures and operational procedures adjusted to address the changed fire vulnerability related to electric GSE both for ground personnel and flight crews. Ground procedures are assessed and adjusted to reduce the likelihood of aircraft impact in case of electric GSE fire (e.g., positioning of GSE further away from the aircraft so that the aircraft is not damaged in case of fire).
Photovoltaic installations (PV) at buildings and on ground within or close to the airport premises could create hazards for aircraft operations (e.g., glint and glare for flights).	Aviation regulators cooperate with photovoltaic installations relevant regulators and operators to ensure risk of affecting ATM surveillance capability is properly addressed. Aviation safety risk assessment is performed for hazards arising from solar polar plants near aircraft movement areas. The risk assessment includes safety clearances on the ground, obstacle limits, effects on CNS, risk of glint and glare, runway safety and impacts on rescue firefighting services and emergency planning and management. Locations and system specifications (e.g., azimuth/tilt angles of PV-panels, panel material) of photovoltaic installations ensure acceptable risk.

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	Aviation regulators establish a risk assessment framework to ensure a consistent standard of evaluation in identifying risks and deriving risk mitigation measures. The permission /contractual provisions for photovoltaic installations contain provisions for mitigations of risks identified during operations.
Increasing the photovoltaic installations at buildings and on ground within or close to the airport premises could affect firefighting tactics, equipment and reaction times when installed on the ground.	Firefighting practices and procedures and operational procedures adjusted to address the challenges imposed by photovoltaic installations.
The increase of electric consumption could introduce pressures on electricity supply disruptions and interruptions.	Aviation organisations are aware and address through their risk management process the electricity supply pressures.
Pressure to improve biodiversity at and around airports may increase the risk of airport animal hazards.	Aviation organisations are aware and address through their risk management process the increased exposure to aircraft animals' encounters.
Pressures for using less fuel and for less noise in flight could lead to use of drones for CNS calibration and measurements.	Using drones for CNS measurements supports sustainability and at the same time could reduce safety risks (higher accuracy of the measurements, less duration of flight operations, especially reducing night time flight operations and less disturbance to ATC).

3. Pressures on the aviation system stemming directly from the climate change:

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For all the pressures on the aviation system stemming directly from the climate change	Aviation organisations perform climate change assessment.
Sea level rise and storm surge could increase the risk of airports flooding and runway contamination.	Airport Authority Risk Management (e.g., see this case: https://skybrary.aero/sites/default/files/bookshelf/4988.pdf). Airport operators and local ATC coordinate in risk assessment and support preparing airport briefings for flight crew to enable comprehensive information. Barriers are implemented to protect airport and ATC infrastructure from flooding.
Temperature changes could make more airports performance critical in terms of current certification assumptions. This can affect the required runway length, the aircraft payload and the existing safety margins.	Aircraft operators expand their operational monitoring and hazard identification to cover the effects of temperature changes in order to critically assess the type of aircraft used on certain routes as well as possible reductions in aircraft payload or rescheduling of flights to cooler times of day to prevent flight crews from operating at or near the physical limits of their aircraft. Training and awareness of aircraft performance issues is provided to airline network planning, route analysis team and to flight crews.
Temperature changes (both cold and hot) could lead to more frequent damages to runway surface.	This topic is monitored by the local runway safety teams and relevant information is fed back to flight crews via airport briefings. Aircraft operators take extra care or reduce check intervals of aircraft wheels when operating on runway surface showing damage. Airport operators perform risk assessment for possible runway or taxiway damages that might occur in extreme conditions, and especially during pavement work to determine mitigation measures accordingly. Airport operators are aware and address through their risk management process the risk of increased temperature variation impact on runway surface.
Larger / more intense convective systems could affect multiple hub airports and impose risk in case of mass diversions.	Aircraft operators use risk approach and adjust their alternate planning accordingly, e.g., by listing multiple alternate options for flight crews which are timely adapted to traffic peaks at that hub. Dynamic capacity balancing is used to distribute diverted flights to airports with available capacity.
Larger / more intense convective systems could increase the likelihood of lightning strikes.	Aircraft operators review their operations manual in regard to dealing with adverse weather. They consider implementing clear distance limits to convective weather, both enroute and during take-off, approach and landing, if not already implemented to assist flight crews in safe decision-making.

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Larger / more intense convective systems could increase the risk of operations disruptions, including, delays, re-routings, route extensions, trajectory management, flight efficiency, increased fuel burn and emissions. These could impose pressures on operations and result in reduced safety margins if not properly managed.	Aircraft operators ensure easy access for their flight crews to weather reports, updates and forecasts, including real time turbulence information, both inflight and on the ground to facilitate intelligent fuel decisions. Flight crews are informed about time of peak traffic on the day when making their fuel decisions.
Increase in both the frequency and strength of moderate and severe en route clear-air turbulence could increase the risk of passenger and crew injuries and aircraft damage.	Aviation industry develops and implements better forecasting and current weather nowcasting tools and infrastructure to provide flight crews and dispatchers with accurate enough information regarding the location and severity of turbulence. Technology is developed to detect more accurately clear air turbulence in flight. Aviation industry develops and implements a global platform for sharing automated aircraft-sourced turbulence reports in real time. Aircraft operators ensure that their operational flight plan and flight crew briefing packages contain accurate temperature, wind and shear level information.
More frequent significant weather phenomena such as heavy rain or more intense thunderstorms could increase the risk for runway excursions or aircraft damage.	Aircraft operators ensure that their flight crews always use safety orientated rather than mission completion orientated decision-making regarding their departure, approach or landing decisions. Go-arounds and diversions should be promoted as well as conservative approach planning especially in adverse weather situations.
Changing wind patterns could increase the possibility of runway crosswinds.	Local runway safety teams take a risk-based approach in determining the optimum use of runway direction in relation to cross- or tailwind operation. Aircraft operators allow reduction of crosswind limits by their flight crews depending on actual circumstances and human factor influences such as fatigue, proficiency, status hierarchy, etc.

4. Pressures on the aviation system to manage aircraft noise and local air quality:

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Pressures to reduce aircraft noise around airports increase the safety risk for flights.	Aviation regulators, airport operators and ANSPs adopt a balanced approach to aircraft noise, considering safety during all phases of operations planning and execution that include reduction of noise at the source, land-use planning and management, noise abatement operational procedures and operating restrictions. Aviation regulators ensure that any noise mitigation rules required to be implemented by aerodromes should be subject to regular and coordinated hazard identification and risk assessment, , both by aircraft and airport operators, to ensure they do not increase the likelihood of runway excursions, in particular in relation to operations on wet, slippery or contaminated runways or the likelihood of bird strikes due to prolonged flight at low level or difficulties in achieving SID procedure design gradients, e.g. with significant tailwind component aloft. Flight crews are not restricted by environmental constraints in their safety related decision making - e.g., when runway conditions are uncertain or actual or anticipated slippery wet, slippery or contaminated, to fully use all deceleration means, including reverse thrust irrespective of fuel, engine wear, FOD damage or noise-related restrictions or when deciding upon the type of NADP to be used. Flight crew training includes vertical speed-airspeed relationship and proper use of vertical speed below FL070. Flight crew are preferably cleared for an entire arrival procedure, with minimal changes below FL070.